ZOOLOG

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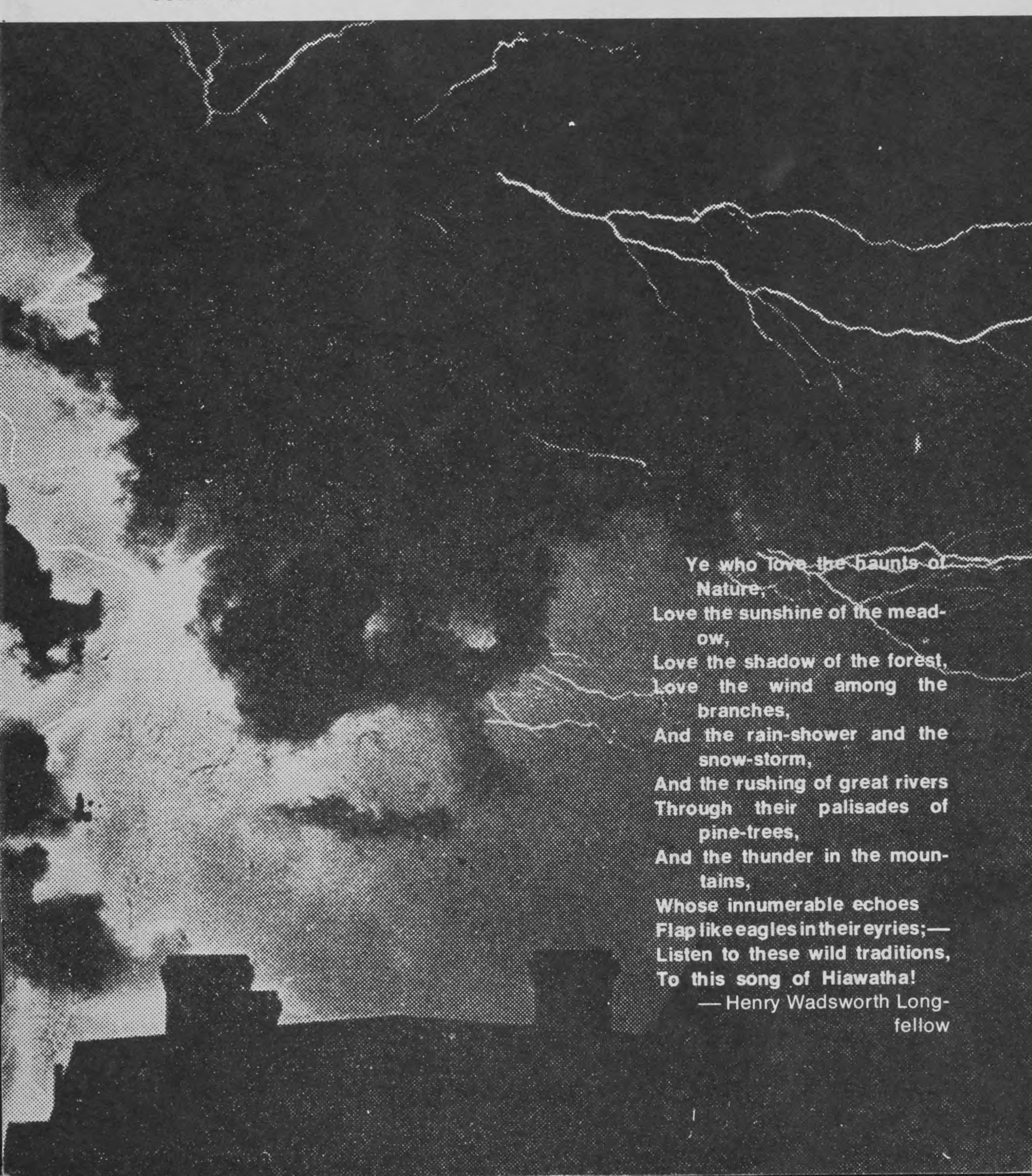

Ye who love the haunts of
Nature,
Love the sunshine of the mead-
ow,
Love the shadow of the forest,
Love the wind among the
branches,
And the rain-shower and the
snow-storm,
And the rushing of great rivers
Through their palisades of
pine-trees,
And the thunder in the moun-
tains,
Whose innumerable echoes
Flap like eagles in their eyries;—
Listen to these wild traditions,
To this song of Hiawatha!

— Henry Wadsworth Long-
fellow

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Chairman's Message

Well, it's good-bye to Gunter Voss! Some of us who have been around the Zoo circuit for quite a few years will well remember the excitement of hiring the first full-time Director for the Assiniboine Park Zoo. It all happened 11 years ago now, not too long after the formation of the Zoological Society of Manitoba.

At the request of the City of Winnipeg, the Society was asked to participate in screening candidates for the position of Zoo Director and, in fact, if I remember correctly, the Society even paid some of the travel costs involved in having Dr. Voss come from Germany for his first interview. Little did any of us expect that the young man from Krefeld would make such a massive contribution to the development of our zoo which at the time of his arrival was much smaller than what we have today.

It has been my pleasure to work directly with Dr. Voss through many of his years here in Winnipeg and I have a keen appreciation of the problems he faced and surmounted in bringing into existence a master plan for the Zoo and overseeing much of the construction this last decade. There is no doubt that he is leaving our Manitoba community a far better place and we wish him well as he sets about the task of developing a new zoo for the people of Toronto.

George Heffelfinger

HAROLD HOSFORD

Although it may be a departure from the usual format of "Zoolog", I feel that it is timely to comment on Harold Hosford's decision to leave his native Manitoba for the warm, wet, winters of Victoria. His departure is a real loss to our province, especially to those who are interested in natural history.

Harold could be described as a "natural" naturalist. His impressive fund of nature lore was not confined to birding, his foremost interest, but extended to all aspects of the "great outdoors".

He could talk and write with authority on a diversity of subjects that was difficult to refute simply because his expertise was based upon diligent observation in the field over many years.

Although he will be missed particularly in the Natural History Society Harold was known to an even greater public in his official capacity as a Conservation Officer with the provincial government, as the author of "Wild Wings" in the Winnipeg Tribune for several years, as the resident Weatherman in C.B.C.'s "Information Radio", as an excellent wildlife photographer, and by no means least as a regular contributor to "Zoolog".

Those who knew him personally will miss him for his particular brand of humour and for his warm comradeship, even fewer people will miss him for his extraordinary baritone singing voice.

Good luck and goood health Harold!

Peter M. Press

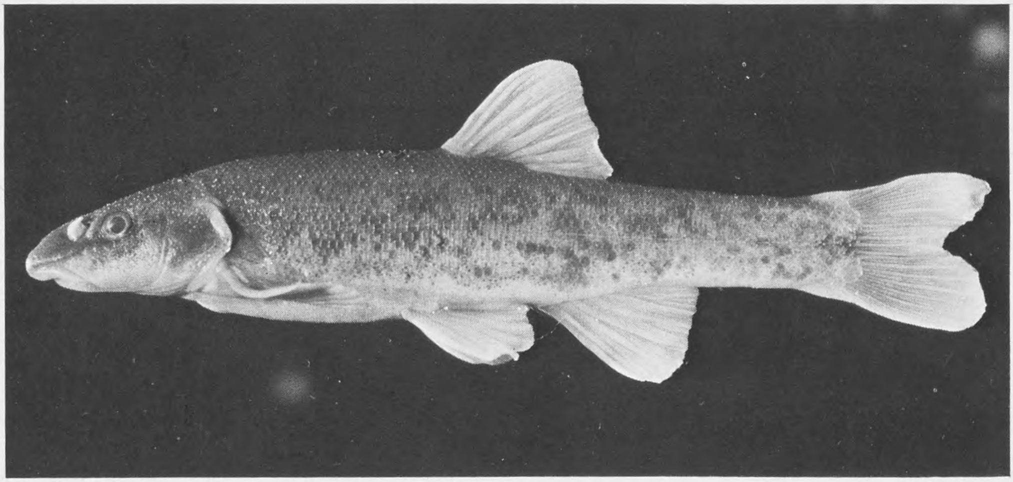

Figure 1. An adult Longnose Dace approximately three inches long. Note the snout in front of the mouth.

The Spawning Behaviour of Two Species of Dace in a Stream Aquarium

Two species of dace belonging to the minnow family (Cyprinidae) are common in Manitoba streams. These are the Longnose Dace (*Rhinichthys cataractae* — Fig. 1) and the Blacknose Dace (*Rhinichthys atratulus* — Fig. 2). In nature both spawn at the end of May and the beginning of June, although many Longnose spawn before Blacknose. The eggs require about 7-12 days to hatch, depending on water temperatures. Following hatching alevins remain in spaces in the gravel out of sight of predators and protected from the current. This is quite important because they are unable to move quickly or with ease. In this stage the alevins utilize the yolk reserves of their bodies for food which lasts about 4-7 days. Then comes a very critical stage, for next they must leave the safe confines of the gravel and search for good. At the same time they must fill their swimbladders so that this organ can act as a float to keep the fish suspended in mid water allowing them to move about with relative ease to capture food and escape from predators. The initial filling of the swimbladder is accomplished by the small fish, now called fry, by darting to the surface and gulping air into their mouths. It is then passed through a small duct into the swimbladder. The swimbladder is located just under the spinal column. Once this feat is completed the fry can swim with great agility.

In the first few weeks fry spend most of their time in still water in the shallow areas near the stream bank where larger predators cannot enter. But near the end of the summer juvenile dace are found away from these protected nursery areas. And, in fact, juvenile Longnose start to move out into moderate velocities of water. This change in habitat of Longnose Dace continues and by the end of the first year of life this species is found living almost entirely in rapids and riffles. But Blacknose Dace continue to live in still water and occasionally venture out into moderate flowing velocities. By the time adulthood is reached at the

age of two years, these two closely-related species are found in quite different places in the same stream; Longnose in rapids and Blacknose in pools and channels.

These differences between the two species in habitat are reflected in the places where they spawn and in their patterns of spawning behaviour. The choice of a spawning site where eggs are to be deposited must be very precise as certain requirements must be met. The eggs must be (1) protected from sight from predators, (2) placed in a silt-free area where they will not smother, (3) protected from mechanical damage by a shifting substrate, and (4) placed in such a way as not to be washed downstream where they could settle out in an unfavourable area. By searching all areas in streams and locating nest-sites, we have found that Blacknose bury their eggs in small stones or gravel where the water velocity is slow. Thus the eggs are hidden from view and water currents keep the gravel free from silt. In addition, eggs become adhesive as soon as they leave the female and stick to the surface of the gravel. Eggs of Longnose Dace are also adhesive but they are not buried. Nest-sites are located between large stones and rocks in very fast rapids. Eggs deposited in such crevices are out of sight and in this way the above requirements are met.

The spawning behaviour of stream fishes is often difficult to observe in nature because of the turbulent water. But some observations can be made by lying in the stream with a wet-suit, face-plate, and snorkel. Even this is difficult in the shallow waters where these two species of dace often spawn. To overcome such problems, two steam aquaria were designed each of which gave the spawning resources of current and substrate required by the dace. These aquaria were constructed of an angle-iron frame with plate-glass sides and bottom. The basic plan is shown in Figure 3.

The air-stones, 12 inches long, were connected to a compressed air system. Fast-rising bubbles from the air-stones lifted water at that end of the aquarium and caused a current of water to strike the deflector plate. Water currents then passed along the surface over a false bottom, down the opposite end, and then along the bottom of the aquarium. This resulted in a circular current of water on a vertical plane. Stones and gravel were spread over the false bottom to provide the substrate. The false bottom was suspended by stainless steel wires from the top frame of the aquarium. Fish were retained over the false bottom by stainless steel screens running across the width of the aquarium at either end of the false bottom.

Blacknose and Longnose Dace were captured from streams in the Duck Mountains and brought into the laboratory prior to spawning. Blacknose Dace were placed in one stream aquarium which contained gravel and had a slow water velocity. Longnose Dace in the second stream aquarium were provided with large rocks for a substrate and were exposed to a very fast water velocity. Fishes in both aquaria were exposed to a steadily increasing day length and water temperature similar to that which they would receive in nature. They were fed Tetramin flakes, frozen brine shrimp, and white worms.

Once these fishes had become familiar to their new surroundings, patterns of behaviour could be observed. Over the first two weeks in late April, individuals of both species appeared inactive in the cold water, spending most of their time hidden from view close to the bottom. Occasionally, when one fish encountered another, mild forms of aggression would take place but these were rare as fish tended to ignore or avoid one another.

But early in May when the water warmed up and the day length increased, fishes became more active and males of both species took on a spawning colour. Males of Longnose Dace display a bright crimson colour on their lips, cheeks, and at the base of their pectoral, pelvic, and anal fins. Males of Blacknose Dace have a different spawning colouration consisting of a bright red band along each side of the body.

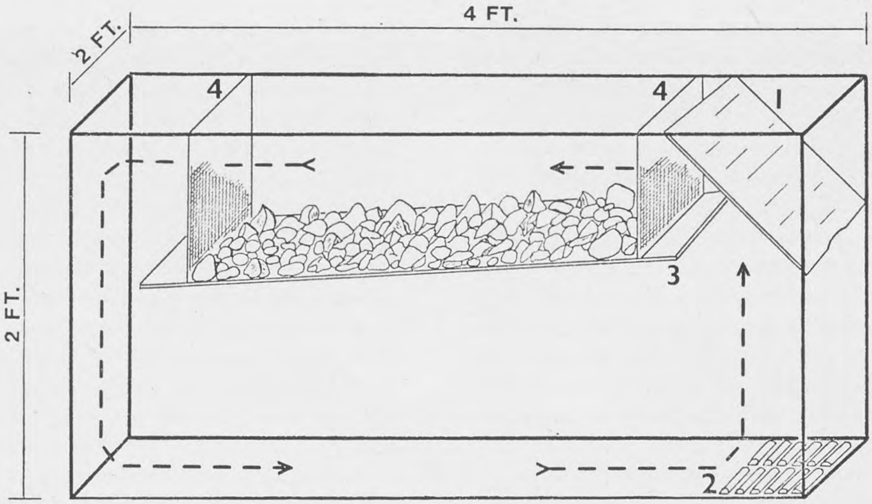

Figure 3. Diagram of stream aquarium. The arrows indicate the direction of flow. 1 = deflector plate; 2 = air-stones; 3 = false bottom; 4 = screens. The plastic tubing supplying compressed air to the stones has been omitted.

Concurrent with the development of this colouration is the appearance of territorial behaviour by males of both species. In other words, these males guard or defend small areas of the stream bottom. Within each territory there is a small central station at which the occupant spends most of its time and where it displays the maximum aggressiveness. Quite often this station eventually becomes a nest-site.

A maximum of five territories were established at any one time in the stream aquarium containing Longnose Dace. The areas guarded by each male were about 4-8 inches in diameter. Territories held by Blacknose Dace were considerably larger, 12-24 inches in diameter as indicated from observations in natural streams. Only one or two could be held at any one time in our stream aquarium. Territorial behaviour by males of both species commences early in May and increases in intensity as spawning time approaches. At first territorial males are aggressive to both other males and to females. As spawning approaches they remain aggressive to other males but attempt to entice females onto their territories. Territorial Longnose males show aggression to intruders by darting and biting at the intruders or by butting their heads against those of the intruders. Often the intruder would return such a a butt resulting in savage fighting often with the combatants exchanging blows for as long as 60 seconds. Aggressive behaviour by Blacknose males is somewhat different. They will dart at an intruder and often give chase, biting at the tail of the fleeing fish. Quite often the intruder will not flee and will turn around and bite at the defending territorial male. This often results in both males chasing one another in a round about circular manner making many rotations as they drift downstream.

One can easily see that the patterns of aggressive behaviour of males of both species is ideally suited for the different velocities of water in which they live. The Longnose male cannot afford to make extensive movements in the fast-flowing water because of the danger of being carried downstream. Hence its aggressive behaviour is limited to biting and head butting. Thus its territory is smaller than that of Blacknose males. The latter species, whose territories are guarded in slow-moving water, is more mobile. Its territories are larger and aggressive behaviour patterns are composed of chasing and darting which often take place over several feet.

Just prior to spawning, males of the two species remain aggressive to other

males but start to entice or court females near their territories. In order to do this, such males must be able to distinguish between other males and females of their own species. Males are distinguished by their distinctive spawning colour while females are recognized by their white bellies distended with eggs.

Just as the territorial behaviour differs between the males of both species, so do their enticement and spawning behaviour patterns. Longnose males entice females by nudging their noses between stones over the station of the territory. This is often followed by a rapid quivering of the body which is angled at 45-90 degrees from the bottom. If the female is attracted by this display and is ready for spawning she will swim along side the male and both will probe the bottom with their noses. Then the two fish assume a position side by side on the bottom and the pair, touching sides, quiver for 1-2 seconds during which eggs and milt are released. Following spawning the female leaves the territory and the male may spawn again with other females. The female does not release all her eggs at once and she too may spawn again. One female in our stream aquarium spawned five times over a one hour period.

The Blacknose male is much more mobile in his enticement behaviour. He will often swim out to greet a female when she approaches his territory. This is followed by the male nibbling and nudging the female. If she is receptive, the male will attempt to maneuver her over his station by "dancing" in a zig zag movement in front of her. When the female is maneuvered over the station, the male swims along side her and she arches her body thrusting her anal fin into the gravel. The male throws his tail over the female holding her against the bottom. Both quiver violently for 1-2 seconds releasing eggs and milt into the gravel. The violent quivering displaces some of the gravel so that the fertilized eggs become buried. Again, both males and females may spawn a number of times during the spawning season. Males of both species remain territorial after spawning for up to four days and in this way guard the nest-site containing eggs.

Thus both species possess a complex series of behaviour patterns which have evolved to increase the chances of reproduction and survival of eggs. The differences in patterns of behaviour between each species is a reflection of the different environment in which each lives.

J. H. Gee,
V. G. Bartnik,
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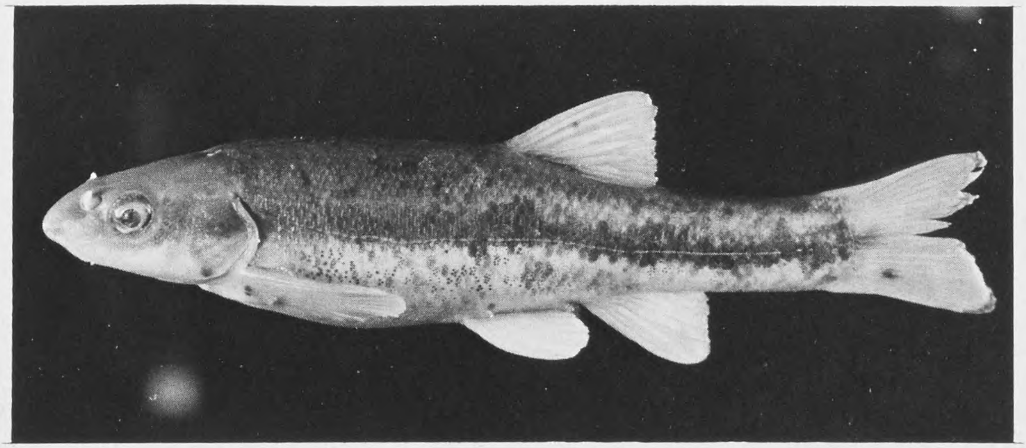
Figure 2. An adult Blacknose Dace approximately three inches long distinguished by a solid dark lateral band.

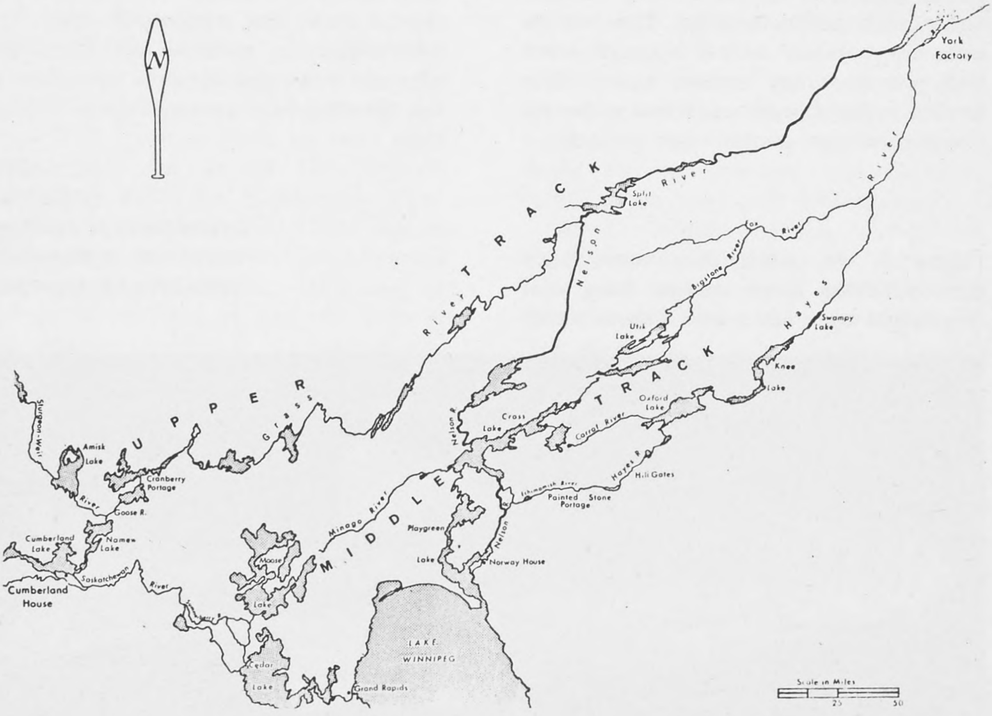


1968

York Factory — Main Depot

1968

York Factory — Hayes River



Transportation Routes in the Nelson-Churchill Hayes River Trough

From Eric Norse, "Fur Trade Canoe Routes of Canada Now and Then", Queen's Printer, 1968

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MANITOBA RIVERS

Dr. R. W. Newbury,
Associate Professor,
University of Manitoba,
Civil Engineering.

PART III

RIVER ENGINEERING

The physical processes that produce and maintain Manitoba's Rivers were discussed in Parts I and II of this series. Man's influence on the pattern and timing of our drainage system was ignored, perhaps deliberately; for even the most complex "engineering" of rivers does not fully comprehend the logic and finesse of natural river processes. Yet in Manitoba we have grossly re-arranged most of our rivers to suit our present day needs with curious blend of innocence and optimism.

Man and rivers in Manitoba have not always suffered this disharmony. The Nelson Churchill trough, described in Part II as a drainage anomaly that traversed the Canadian Shield was also a transportation anomaly. The Hayes River route, bordering the southern edge of the trough, was the Hudson's Bay Company "highway" to the interior for more than 200 years with trade goods travelling upstream and furs travelling downstream. The interior tributaries to the Nelson were the distribution routes; conveniently to the East, South and West. York Factory, now abandoned on Hudson Bay, was the principal depot and hub of activity. It is perhaps a reflection of agricultural chauvinism in the South, that the rivers were better known 250 years ago than today.

In the last few decades, we have returned to Manitoba's rivers, not for transportation but for power. We started in the South on the Winnipeg River and have moved north with increasing rapidity to the Nelson, Churchill and Seal Rivers. The engineering is bigger and better organized but now almost totally removed from the rivers themselves. Design engineers don't often paddle canoes.

Our efforts to engineer rivers have often been described with triple dams but this could be extended in a simple way to the 4D's of a river engineering primer: DAM, DIVERT, DUMP AND DYKE.

DAMS

The first D, for DAM, predominates in Manitoba. The slope and flow of a river dissipates power but unfortunately in small increments along the channel. A dam concentrates the slope or fall at one location and allows us to line up the flow with some rather large propellers that turn generators. We have done this at six locations along the Winnipeg River in Manitoba and managed to concentrate over 90% of the fall.

We then moved to the next suitable river, the Saskatchewan, and concentrated its fall in Manitoba at Grand Rapids. Since power requires both fall and a large volume of water, the Red and Assiniboine with relatively low average flows were not suitable. By the 1960's, we were forced to move still farther north to the Nelson River at Kelsey and Kettle Rapids. By early 1970 about 1/3 of the Nelson fall will be concentrated by dams at these two locations.

There are other reasons for dams as well. For example, the power dams provide reservoirs for storing water until we need it (our maximum demand.

for power and the maximum natural supply of water are out of phase by about 6 months at this latitude). The smaller dams in southwestern Manitoba are usually built to store water for domestic consumption or waste disposal or perhaps to hold back flood waters for a more gradual release.

DIVERSIONS

The second D stands for DIVERT. In Manitoba we have several scales of diversion. The aqueduct that transmits domestic water to Winnipeg from Shoal Lake is probably the smallest but nevertheless the most important diversion. The diversion of flood waters around Winnipeg in the Floodway or into Lake Manitoba from the Assiniboine River are the largest diversions constructed to date. The controversial Churchill River diversion as last described would simply divert the northern outlier of the Nelson-Churchill trough into the center of the trough to provide more water over the same fall at Kettle Rapids. The power economics of this scheme are not tricky, one dam that passes two rivers is more economic than a dam on each river. There are good and bad ways to realize this economy from the viewpoint of the local population and the countryside but the good ways require skill.

DUMP

The third D stands for DUMP and is something that everyone in Manitoba can manage. Sanitary engineers know that organic wastes decompose aerobically providing a supply of oxygen is available. In fact, they can measure the oxygen demand of a given slug of waste. When the slug is placed in a flowing river such as the Red, the dissolved oxygen in the water is rapidly consumed but at the same time replenished from the atmosphere. When the consumption exceeds the replenishment rate as the slug moves downstream the amount of oxygen in the water decreases or sags. When it sags to zero fish and river bank dwellers are not pleased.

We have our own problems in Winnipeg in operating this system on the Red as the flows occasionally diminish to zero. However, the gated dam at Lockport built to assist navigation in the early 1900's creates a fine detention basin that extends through Winnipeg to hold our slug until the flows pick up again.

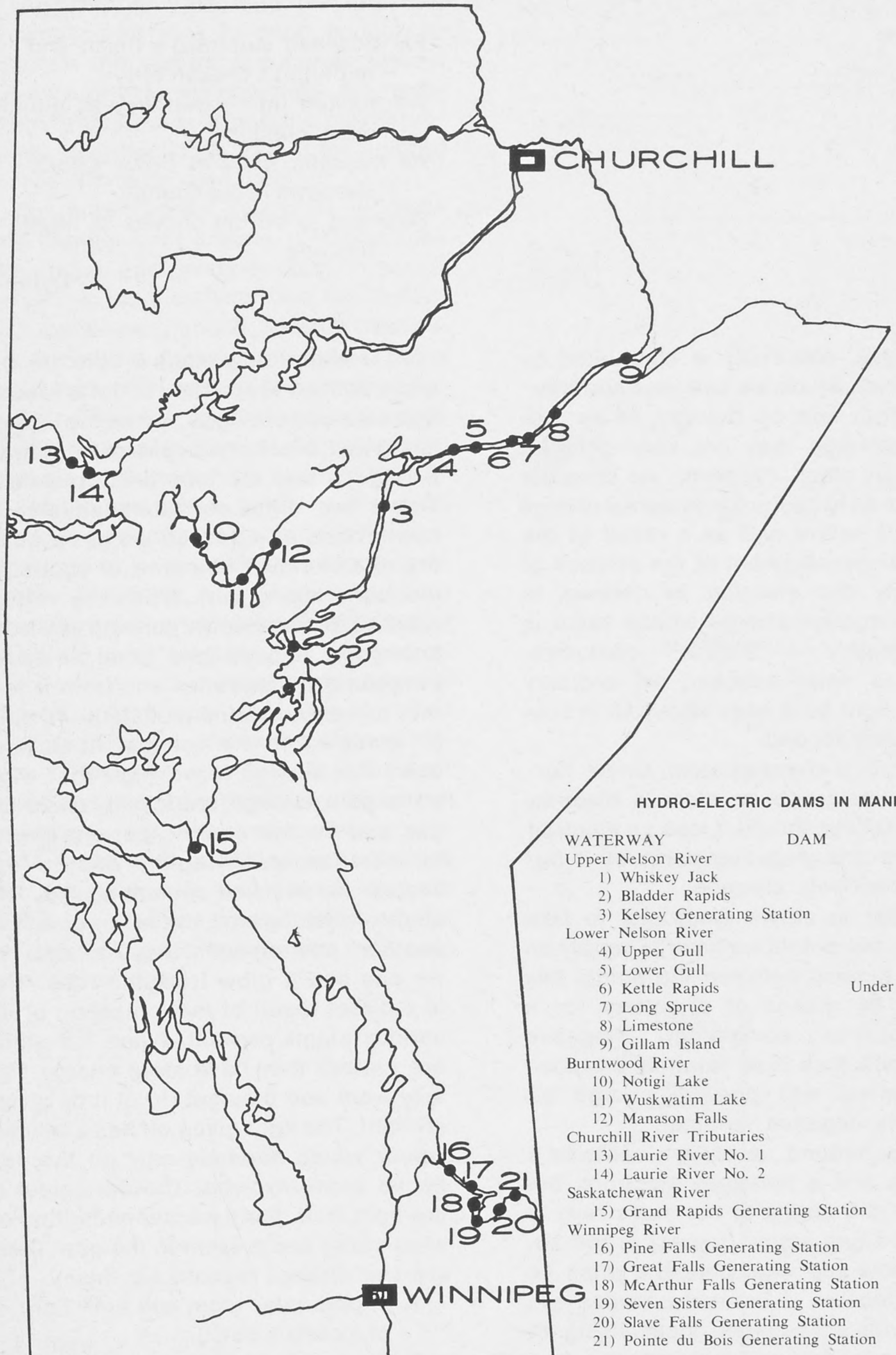
DYKE

The fourth and final D stands for DYKE. Most dyking efforts can be linked to a peculiar cultural trait (so I am told by Anthropologists) that we could call a "Cartesian Mentality". In other words, we have squares on the brain. Our streams, lakes, and rivers do not suffer this affliction and simply meander or braid or erode themselves in their natural form across property lines. In most of the areas in the province we insist that this behaviour stop and force the drainage pattern into 99 foot road allowances with right angle turns by ditch and dyke combinations. This requires extensive maintenance but it's worth it to the survey system. Of course, where the erosive power accumulates in a larger river or lake, for example Lake Winnipeg we must also try to escalate our efforts.

In a final and more serious vein, it would be remiss not to discuss the future of Manitoba's rivers. As it should be obvious, Manitoba has an inheritance of water environments that is unique in North America. Many of these environments have been simply ignored in the past because of their number, small deserted Canadian Shield lakes for example. To most Manitobans this environment is still commonplace.

We are surrounded however, by regions that have not enjoyed an unpolluted and relatively uninhabited water body in many decades and the demand to use our resources has just begun. These resources can be shared, enjoyed and developed economically if we acquire some understanding of natural processes and adopt skill and finesse as well as economics as design criteria.

We are not organized to accomplish this in Manitoba. In the past, any resource development that smacked of the slightest real or potential economic gain was assigned a planning and management organization. A similar commitment should now be made to the resource of Manitoba's environment.



HYDRO-ELECTRIC DAMS IN MANITOBA

WATERWAY	DAM	STATUS
Upper Nelson River		
	1) Whiskey Jack	Proposed
	2) Bladder Rapids	Proposed
	3) Kelsey Generating Station	Existing
Lower Nelson River		
	4) Upper Gull	Proposed
	5) Lower Gull	Proposed
	6) Kettle Rapids	Under Construction
	7) Long Spruce	Proposed
	8) Limestone	Proposed
	9) Gillam Island	Proposed
Burntwood River		
	10) Notigi Lake	Proposed
	11) Wuskwatim Lake	Proposed
	12) Manason Falls	Proposed
Churchill River Tributaries		
	13) Laurie River No. 1	Existing
	14) Laurie River No. 2	Existing
Saskatchewan River		
	15) Grand Rapids Generating Station	Existing
Winnipeg River		
	16) Pine Falls Generating Station	Existing
	17) Great Falls Generating Station	Existing
	18) McArthur Falls Generating Station	Existing
	19) Seven Sisters Generating Station	Existing
	20) Slave Falls Generating Station	Existing
	21) Pointe du Bois Generating Station	Existing

Note: Map keyed to table.

THE CHIMES OF FREEDOM

"Far between sundown's finish and
midnight's broken toll
We ducked into a doorway as thunder
went crashing.
As majestic bells of bolts, struck
shadows in the sounds,
Seeming to be the chimes of freedom
flashing."

B. Dylan

In a gas, electricity is conducted by two entities which we call ions and eletrons. Both can be thought of as particles although they are very different from each other. Presently we consider the electron to be the fundamental charge carrier of nature and as a result of the historical development of the science of electricity the electron is defined to have a negative charge whose value is approximately -1.6×10^{-19} coulombs. This is a small number, an ordinary electric light bulb uses about 10^{+2} coulombs every second.

An ion is a charged atom. Under normal circumstances an atom is electrically neutral but should it lose an electron (i.e., lose one negative particle) it becomes positively charged.

In order to cause electricity to flow between two points we have to supply an electric tension between the points this is done by means of a battery (or a generator or something). Negative charge will then flow towards the positive terminal and positive charge towards the negative terminal.

The air around us always contains a few ions and a few free electrons because of the ability of the sun's rays to ionize the gas atoms present in the air. Let us now see what happens when an electric tension is created between two points with air between them. In figure 1 three experimental arrangements are drawn; only in Fig. 1(a) is it easy to study the relationships which exist between the current flowing and the electric tension between the electrodes. From such an experiment we would obtain the results sketched in Fig. 2.

At O where the voltage is zero the ions and electrons are drifting about at random and zero current flows. When the voltage is applied, electrons begin to drift toward B (Fig. 1) and the ions drift towards A. These two drifts constitute an electric current and in a second we get a quantity of electricity indicative of about 100 electrons taking part. When the voltage reaches B the electric tension is strong enough to remove ions from the space between the electrodes and from B to C the current remains constant in spite of increases in the voltage. At C, however, the tension is so high that electrons gain enough energy to ionize the gas and so the electric current begins to increase quite rapidly and in one second we will find something like 10^{13} electrons taking part. It is at this point that another phenomenon occurs, that is, we can see a glow from the tube. This is a direct result of the ionization of the various atoms present. When the atoms are ionized they have more energy than they want and they get rid of it by giving off light. The light given off has a definite colour which depends only on the particular atom involved. The net colour of the light from the tube depends then on what atoms are present in the gas. There are two distinct reasons for this:

1. A particular atom will emit light of a certain colour.
2. Under special circumstances another, different atom, can absorb this light so that it never gets out of the tube.

By studying the colour of the light from this so called glow discharge we can find out what atoms are present.

To continue with our current voltage curve, we have come to the point D. At D the tension is so high that the rate of creation of ions is great enough to maintain the electric discharge without the help of external agencies, the resistance of the gas falls and the current remains fairly constant so that the voltage across the tube also falls.

The current then begins to increase very rapidly until around 10^{20} electrons are taking part every second at which point F is reached and then the system arcs between A and B, usually destroying the whole experiment, unless some resistance is placed in the external circuitry. The arc has of course some of the characteristics of lightning, but then so does the whole experiment.

Let us now briefly consider Fig. 1(c). Here we have charged electrode B negatively using some electric charge generator. Electrode A is insulated and so the negative charge on B pushes negative charges away towards the far end of electrode A and induces a net positive charge on the near end. This is called electric induction. When the electric tension between A and B is high enough these positive charges will stream across towards B. It is not unreasonable to suppose that under suitable circumstances the situation will correspond to parts C,D,E in Figure 2 and electrode A will appear to be surrounded by a halo of visible light.

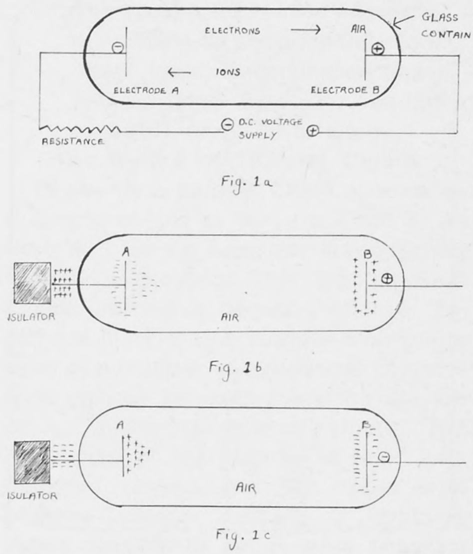


Figure 1

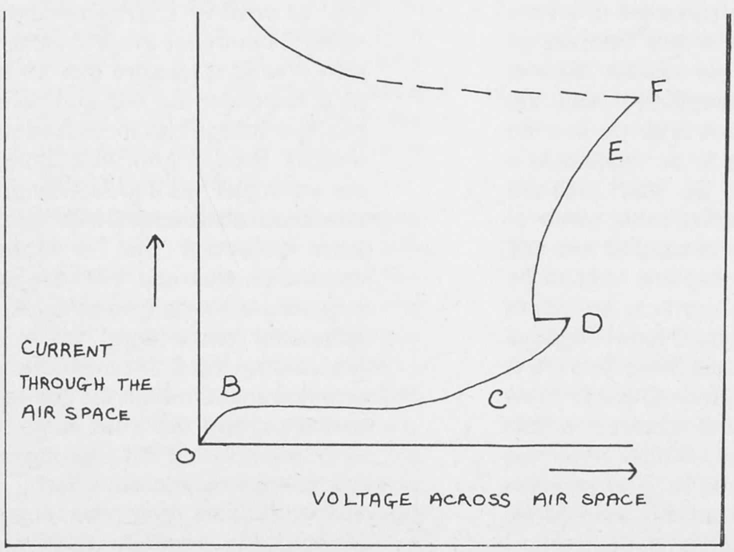


Figure 2

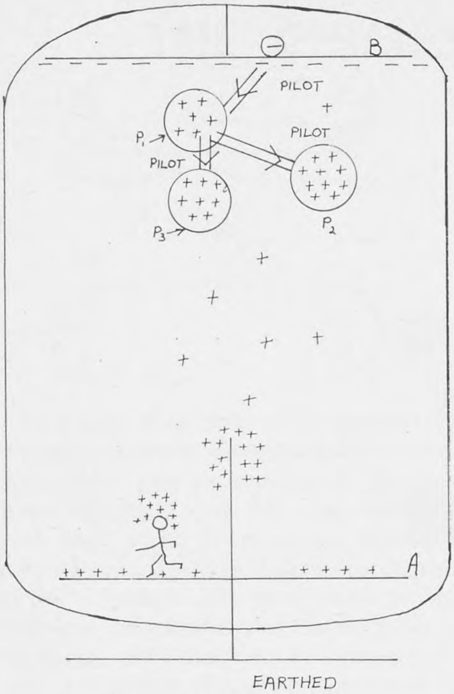


Figure 3

A Thought Experiment

The reader may now be asking what these puny experiments have to do with the giant flashes of light and great bangs and rumblings of the average thunder and lightning storm. Let us therefore stretch the scale of our experiments but now only in our minds. In figure 3 experiment 1c has been rearranged slightly. Electrode A now takes the form of a flat plate with a spike on it, a man has been included in the interest of verisimilitude and the whole system has been rotated through 90°. Now the picture emerges that A is to be likened to the earth and B is to be likened to a thunder cloud. Now we may proceed with our thought experiment; some of the processes to be described are still not well understood but are held to be at least qualitatively correct. As before the negative charges on B repel negative charges away from the near end of A but they flow right away to earth leaving the near end of A covered with a net positive charge. Notice that the whole area beneath B is also charged and that the charge density is greatest at the spike end over the man's head.

We will now list the processes which are supposed to occur in their time order:

(1) As the tension between A and B increases, positive charge streams out from A, as these ions accelerate they excite other gas atoms in their paths causing them to give off their characteristic light. This effect will be greatest around the pointed areas of A namely the spike and the man's head. These areas will then appear to be surrounded by the haloes of glow discharge, in nature this phenomenon is called Saint Elmo's Fire.

(2) When some of this positive charge comes close to B it is called a positive pocket P_1 and at this stage the electric tension is strong enough to encourage electrons to leave B and move towards the positive pocket. This process will correspond approximately to the region of c in Fig. 2. As these electrons move through the air they ionize the gas atoms so that they leave behind them a trail of positive charges. The process does not normally produce any light visible to the naked eye but it does tend to warm up the gas so that some evidence of the process can be gained with infra red tech niques. This "dark" current has been called a "Pilot".

(3) As the pilot moves towards P_1 the trail of positive charge behind it tends to neutralise the electric tension driving it forward but, so far as B is concerned this additional positive charge has increased the electric tension and, in addition, the warm gas has a greater ability to conduct electricity. B then ejects more electrons into a higher electric tension and this time the excited gas atoms give off a characteristic visible light. We have reached d in Fig. 2. This new stream of electrons is called a "Leader" and it follows the pilot mopping up or neutralising the trail of positive charge behind the pilot.

(4) When the leader has finished mopping up, the pilot can again feel

the electric tension and can again start to move forward towards a new positive pocket P_2 or perhaps P_3 or both. In the latter case the leader will follow both pilot branches paving the way for the well-known "forked lightning". The pilot path is quite random and it will follow the line of least resistance through the air frequently choosing wrongly, branching and re-branching but always, in our diagram, bringing the leader closer and closer to the spike on A.

(5) When the leader is close to A the positive charge on A feels the full effect of the negative charge on B simply because the air between A and B has now been rendered highly conducting by the passage of pilot and the leader and their associated warming up process. The positive charge on A then moves upwards to meet the leader, there is a massive burst of Saint Elmo's Fire which travels all the way back up the leader/pilot trail lighting up first the most direct path to B with a spectacular flash of light and subsequently the various branches and false trails taken by the pilot.

(6) This great gout of positive charge flow heats up the gas to about 15,000°C in the narrow, conducting pilot/leader trail, the time involved is a few millionths of a second so that the gas expands explosively and the result is that a sound wave spreads out from the path taken by the charge. This is what we call Thunder.

(7) If B has been completely discharged by the flash then electrode A will be left with some excess positive charge since for the most part only that charge on the spike will have been removed. This excess charge now flows back to earth and this flow might be especially violent through the man with his highly charged head and although he was not actually "struck by the lightning" he might easily be killed by the flow of electricity through his body. This is called the return shock and is the reason why clever boy scouts do not pitch their tents under trees. Becoming an unwitting lightning conductor can take an awful lot out of a fellow.

The Nature of Thunder Clouds

Of course a thunder cloud is not such a simple object as our electrode B. As early as 1750 the American scientist Ben Franklin discovered that the bases of clouds carried a negative charge. Today we think that a thunder cloud consists of a number of cylindrical columns (one column for each tower on the top of a developing thunder cloud). The lower part of the cylinder is filled with negative charge and the upper with positive charge. Usually a lightning event consists of about three separate flashes to ground. Each flash neutralises a part of the negative charge in the column and it has been found that the parts used lie almost vertically on top of each other. Sometimes these separate flashes can be seen. This is especially true if a very strong wind is blowing across the observer's field of view. The wind shifts the heated return flash path before the second and subsequent leaders begin their downward paths so that the second return flash is displaced from the first and so on. This type of spectacle is referred to as ribbon lightning because of its characteristic striped dark and bright appearance. From careful studies of these lightning strokes it has been found that the top of the negative column is at a height where the air temperature is —40°C. This temperature is that at which all super cooled drops of water must freeze no matter how small they be. It is on this fact that most of the explanations of the charging processes of thunder clouds are based.

Thunder clouds (cumulo-nimbus) usually develop from the aglomeration of cumulus clouds. What we see is a gradual massing of the cauliflower cumulus clouds into a single cloud with a dark base and the characteristic towers on the top. The top of the towers rise to a height where the temperature is much

lower than —40 °C, 7 to 10 miles, while the bases stay ½-2½ miles above the ground at a temperature around 0 °C. Inside the towers the wind direction is upwards, in fact the towers suck warm air into themselves rather like a chimney once the fire is "going well". From studies with balloons and observations on hail stones we can ascertain that the wind speeds must be of the order of sixty miles an hour or more.

It is hard to see how a collection of ice and water blown about by the wind can generate electric tensions of the order of thousands of millions of volts; the secret lies in two reasons. First the large amount of water: a decent thunder cloud cell will have about a hundred thousand tons of water in it. Second in the chemical formation of a water molecule a positive hydrogen ion $H+$ combines with a negative hydroxyl $(OH)^-$ in such a way that the molecule has two "poles" with opposite electric charge. This so called charge polarization is fairly weak but the large number of droplets can give rise to a total charge of 100-1000 coulombs. If the molecules can be broken up in the violent collisions within the tower then it is possible that the correct type of charge distribution can be built up within the cloud. This breaking up is certainly observed in water falls and can no doubt occur within thunder clouds. This mechanism may also contribute positive charge to the "positive pockets" mentioned earlier.

At present, it is felt that the main cloud charging comes from the formation of soft hail when the super cooled water drops reach the critical —40 °C temperature layer in the "generating tower". As the super cooled drops freeze they do so from the outside inwards, a temperature gradient exists that allows the more mobile $H+$ ions to migrate to the outer surface. When the centre of the drop freezes the expansion (water expands on freezing) causes the drop to burst and small positively charged fragments are carried on upwards by the wind and leave behind the larger fragments with a net negative charge. Since all the water droplets will freeze at —40 °C this type of mechanism describes loosely why the negative column extends only to the region where the air temperature is —40 °C, higher parts of the cloud will be cooler and positively charged.

The reader will notice how vague all this sounds and this is because we only understand "in principle" what is going on. To conclude this section it is convenient to end on a clearer note.

Lightning is usually intensely white, this may be altered to yellow or red if the flash is seen through a curtain of rain. There seems to be two reasons for the latter effect, first the filtering effect of the rain drops which absorb the light at the blue end of the visible spectrum; second, lightning produces a fair amount of the gas hydrogen from the breaking up of the water molecules and spectra from both neutral and singly charged hydrogen atoms have been observed. On similar lines the ultra violet emission from lightning is found to be considerably lower than expected; the reason for this is that the leader streamers produce large quantities of the gas ozone O_3 and this gas filters off the-ultra violet light.

The Observed Types of Lightning

We have already met some of the types of lightning, there are others and the list below gives those most commonly seen.

(1) Saint Elmo's Fire — glow discharge effect.
(2) Flashes to Earth — arc/spark effect.
(3) Intercloud Flashes — sometimes called a sheet lightning.
(4) Ball Lightning — usually observed on Victoria Day, the Fourth of July and New Year's Eve.

We have seen how and why Saint Elmo's Fire arises, the question is now where it might be seen in other than the catastrophic return flash form. The answer is that it can be seen when the clouds are close to the gound, for example on mountains or where the ground is flat and featureless and any spikes really stand out. Examples of this are on the prairies when even a steer can become a glamorous fiery headed beast or at sea when ships may be all alight with the "Holy

Glow". Another example of Saint Elmo's Fire is found on objects flying near to thunder clouds. In all cases the sharp points of the objects concerned are surrounded by the brilliant glow discharge.

Flashes to earth and ribbon lightning we have already discussed in some detail, which brings us to intercloud flashes. These flashes are far more commonplace than flashes to earth, which is just as well for everyone's sake. They can be visualized as the neutralisation of part or all of the cloud's charge distribution by a process which occurs within the cloud itself. The effect is wrongly called an intercloud flash since it usually occurs inside one cloud. An associated effect is the air discharge where a lightning flash will start out from the bottom of a cloud but be unable to find a reasonable route to earth. Under these circumstances the flash will travel miles horizontally before neutralisation occurs, sometimes with another cloud or sometimes to ground. "Bolts From the Blue?"

Finally there may be ball lightning and one or two accounts of glowing balls are hard to dismiss but attempts have been made to explain them in terms of burning spheres of gas released from the ground by the passage of lightning through the earth. This explanation might be especially applicable to mountainous regions with dry climates, for there the lightning flashes would be very powerful and tend to follow well defined paths in the ground, streams or marshy tracts perhaps. The electric heating produced might release gases which could ignite. Apparently no meteorologist has ever seen ball lightning, so for the time being we shall not worry about the difficulty of explaining it.

The Effects of Lightning

(1) **On Buildings:** If an unprotected building is struck by lightning it is often destroyed, smashed by the force of the current flowing through it and consumed by fire in the flammable parts of its structure or contents.

A protected building has a conducting rod extending high above it and deep into the ground beneath it. The conducting rod then carries all the current involved in the lightning flash and dispenses it harmlessly in the ground. As the current flows in the lightning rod, however, an electric field is produced along the rod and massive metal objects too near the rod may well be induced to give off sparks which can be just as dangerous as the direct lightning flash. Such metal objects should be attached directly to the rod or earthed independently.

(2) **On Trees:** Trees are often struck by lightning but if they are in wet earth they may not be completely destroyed since the current will flow moderately well through the tree by way of the sap or along wet trails left by rain in the bark of the tree. Under these circumstances a piece of bark may be blown off and this might be the only damage. On the other hand, if the tree has shallow roots or is in very dry ground then it might be blown apart by the heating effects of the current.

(3) **On Aircraft:** Lightning strikes on metal aircraft usually do no harm except to temporarily wipe out communication between the aircraft and its base. This is because the lightning merely uses the aircraft as a better conducting path through the air.

(4) **On Animals:** Animals may be struck by lightning on some occasions or killed by return shocks since they tend to shelter under trees or near to buildings. They may also be disturbed by the noise of thunder. This is probably only true for highly domesticated animals.

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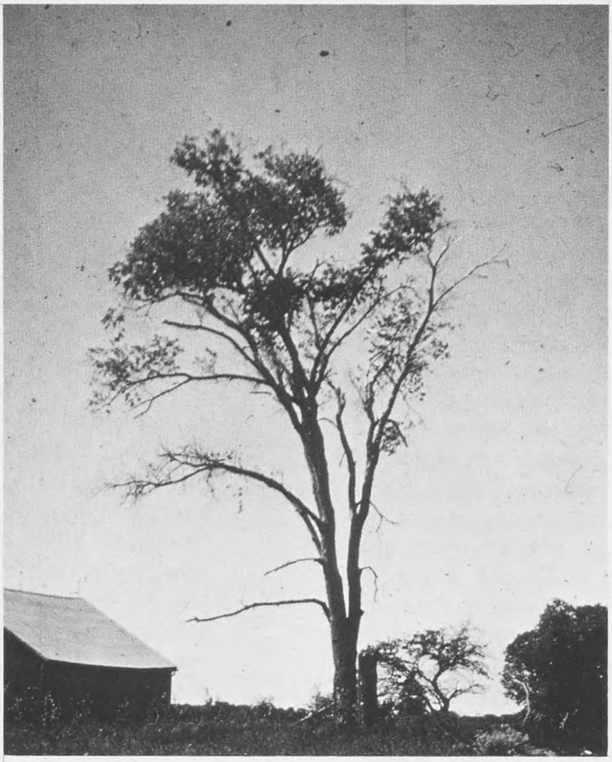

DUTCH ELM DISEASE

THE PRESENT SITUATION IN MANITOBA

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We are all familiar with the white elm, *Ulmus americana,* which graces so many of Winnipeg's streets and parks. Though not commercially important in Canada, the elm cannot be equalled as a shade and ornamental tree throughout its range from Newfoundland to eastern Saskatchewan. Its rapid growth and pleasing form make it ideal for street planting; and on the Prairies it is of particular value, being cold hardy: relatively few other broad-leaved species can be grown here. However, the white elm is very susceptible to Dutch elm disease, notorious for its decimation of elm populations throughout the cities and countryside of N.W. Europe, the United States and Eastern Canada: Ontario, Quebec and New Brunswick. The disease, so called because it was first diagnosed in Holland, has spread very rapidly since it was introduced to North America in 1930 in elm logs imported from Europe for veneer manufacture. This has occurred despite many millions of dollars spent in combatting it.

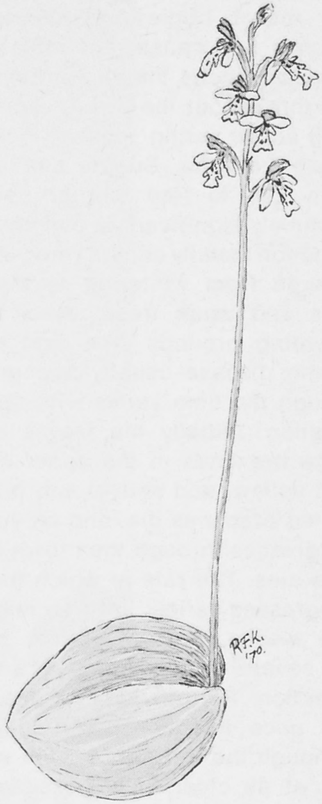
Why is this destructive disease so successful? The answer lies in the nature of the disease itself. The cause of Dutch elm disease is a fungus called either *Ceratocystis ulmi* or *Graphium ulmi.* The two names indicate that the fungus can exist in two different forms; it can produce spores in several different ways so that spore production is high and the fungus is very adaptable. The spores are mainly produced in the moist galleries of elm bark beetles, and it is these beetles which carry the disease from tree to tree. The beetles feed on the small twigs of healthy elms before

breeding, and the spores, carried on the insect bodies, germinate in the wounds and cause new infections. The fungus invades the sap-stream, spreading throughout the wood, especially the long active spring vessels, in a budding yeast-like form. Spores can also pass from tree to tree through root grafts, obviously significant in avenues of elms. Infection usually occurs when the beetles emerge from wintering in the bark of logs and weak trees, which are their breeding grounds. The first symptoms of the disease usually appear by July, though the time varies with season and location. Initially the leaves of one or more branches in the upper crown wilt and yellow, and shrivel and fall. The infected branches die, and as the disease progresses through the crown the whole tree dies. The rate at which the disease progresses varies: the tree may die in a few weeks, a few months, or persist for several years acting as a source of infection. There is little chance of recovery once infection has occurred, and although the reasons for the wilting are not at all clear, it is possible that the toxins produced by the fungus interfere with the water conduction of the vessels so that the tree dies of drought.

It is evident why the disease is so difficult to control. The fungus spreads inside the wood and cannot be reached by sprays, and by the time symptoms appear the tree is thoroughly infected. Obviously the disease must be prevented from reaching healthy trees. Quarantine regulations restrict the transport of elm from areas where the disease is present, but a vital precaution in all areas is effective sanitation, by the destruction by burning of elm logs, stumps or unhealthy trees which can act as breeding grounds for the beetle vectors and a source of infection. The beetle can be attacked directly. If healthy trees are sprayed with insecticides just before the leaves appear the beetles can be killed before infection has occurred. DDT has been widely used but has now been replaced by less persistent but equally effective insecticides such as methoxychlor. Biological controls may be less disruptive to the environment than chemicals, and parasites and predators of the beetle vectors are being tested experimentally for their ability to control the beetle populations.

Not all species of elm are susceptible to Dutch elm disease. The Siberian and Chinese elms as well as some specially bred varieties are resistant. However, all resistant varieties yet found have some disadvantages such as susceptibility to other diseases or lack of cold-hardiness. Attempts have been made to increase the resistance of white elm by the injection of chemicals, a sort of immunization procedure, but the application of this method has obvious drawbacks.

In view of the effectiveness of *Ceratocystis ulmi* as a pathogen and the difficulty of controlling Dutch elm disease, how seriously are our elms threatened? The disease has spread as near as Minnesota and N. Dakota, and the native elm bark beetle occurs in Manitoba and Saskatchewan (though the European elm bark beetle, which has proved the more dangerous vector in the East, has not yet been found on the Prairies). However, the prairie environment is in our favour. For one thing the climate is quite dry: the disease is favoured by more humid conditions. More importantly, except near the rivers of southern Manitoba, elm does not grow in continuous stands. Elms planted in towns, villages and farms are relatively isolated from each other and the chance of the disease spreading from settlement to settlement is therefore lessened. Of course the disease-carrying beetles can fly, and may be transported accidentally for long distances, for example on firewood, but even so the hazard is far less than it was in the East. There are elm diseases on the Prairies, including one very closely related to Dutch elm disease, but at the moment it seems that the elm population is in no immediate danger, and that the continued planting of elm, mixed with other trees, is justified. We should be able to learn from the experience of other areas in preventing Dutch elm disease from becoming a serious problem on the Prairies.



Drawings for Zoolog by Rudi Koes, 1970

JUNE IS ORCHID TIME

John Jack

Want to go "hunting" in June? Try Orchids — they're fun. Scoggan's "Flora of Manitoba" lists 34 species in this province, some big and showy, some small and inconspicuous, but they're all Orchids and some are not easy to find. They are a bit of a challenge, because many grow in out-of-the-way places, some in rather boggy and rough areas.

Equipment? Knee rubber boots, waders are even better. Mosquito repellent, although when one is involved in the hunt the little pests don't seem nearly so bothersome. A hand lens is needed, and a Field Guide. Case's "Orchids of the Western Great Lakes Region" published by the Cranbrook Institute of Science, Bloomfield Hills, Michigan, is very helpful, particularly in identifying some of the rather obscure green orchids. We obtained our copies through the University of Manitoba Book Shop. Take a camera along too, with some close-up equipment.

The Federation of Ontario Naturalists will be interested in your findings as that organization is preparing a listing of Canadian Orchids. Write Mr. H. N. MacKenzie, 228 Royal Ave., Ottawa 13, for a copy of the instructions. Your help will be appreciated.

But let's get out in the field. Start looking in late May or early June. That's when we've found the rare and beautiful Venus' Slipper *(Calypso bulbosa)* in the Jackpine woods. It seems to flower in the same place and about the same

time as the Trailing Arbutus, *(Epigaea repens)*. Another more common species flowering just a little later, in not too damp and perhaps more open forest, is the Moccasin Flower or Stemless Lady Slipper, *(Cypripedium acaule)*.

In dark woods, but not too wet, look for our three Coralroots. The first to bloom is the Early Coralroot, *(Corallorhiza trifida)*, a yellow plant with inconspicuous white blossoms. Two larger species, Striped Coralroot, *(Corallorhiza striata)* and Large Coralroot *(Corallorhiza maculata)* are a red color, they appear a week or so later. These plants are saprophytes, lacking chlorophyll, which makes them rather more interesting, because they have to depend on other plants for their carbohydrates. Dig around the base of a plant and note the form of the rhizomes. The reason for the generic name of these Orchids will be obvious.

Now we can find some of the Green bog orchids, the Habenarias. The green foliage is seen readily, but the plants can go unrecognized as the blossoms are small, ranging from green to white, and quite inconspicuous. The Long Bracted Orchid *(Habenaria viridis var. bracteata)* is the largest and most common. The long green bracts, which greatly exceed the length of the flower, are the recognizable feature. Not quite so easily seen are the Northern Bog Orchid *(Habenaria hyperborea)* and the Blunt Leafed Orchid *(Habenaria obtusata)*.

During the latter part of June, in wet places, one can find the Round Leafed Orchid *(Orchis rotundifolia)*, this is a very pretty flower. The plant is about 6 inches tall, has one round basal leaf and a raceme of beautiful white blossoms, the lips of which are spotted with deep purple. Probably this is the most common and widespread of the Manitoba Orchids.

In wetter areas another beautifully colored flower, the Arethusa or Dragon Mouth *(Arethusa bulbosa)* is found. Similar in size to the Round Leafed Orchid its blossom is rosy purple, shaped as the name implies. We have found this species to be fairly common in the areas we frequent, but according to the flora it is quite variable in location, from year to year.

Of the large orchids the Yellow Lady slipper *(Cypripedium calceolus)* appears in greatest abundance. Though usually found in wet shady areas its habitat is variable and the plants thrive in any reasonably damp neutral soil, given a bit of shade. There are two varieties, large and small, var. *pubescens* and var. *parviflorum*. We have found difficulty in separating the varieties. Size isn't necessarily the key and some authorities consider there is much hybridization. So don't be concerned, just enjoy Yellow Lady slippers or *(Cypripedium calceolus)* as you will.

In wet but more open country there occurs our finest orchid, the Queen or Showy Ladyslipper *(Cypripedium reginae)*. Our best stands grew in a cedar bog which had been logged and burned over. Now the shrubs and trees are growing up again and the number of these beautiful big orchids is dwindling.

Flowering dates are a factor in finding some species. One of our best finds was the Grass Pink *(Calopogon pulchellus)* considered by some to be rare in our country. Several years ago, early in July we found one plant, but for many summers we have not been able to find another. Having some experience of timing with the Moccasin Flower, we went looking for the Grass Pink just after most orchids had passed their flowering period. Forty-seven plants in a small area was our count, what number existed in this large bog we've no idea.

Orchid Hunting is a thrilling sport, and there are sufficient species in Manitoba, accessible with a bit of effort, that almost anyone can enjoy. Many orchid species grow in the bogs and the damp areas, alongside other interesting and beautiful flowers, so slip on your rubber boots and who knows, perhaps you may add to the number of species listed for our province.

Note: Hunt them, admire them, photograph them, **but don't pick them!** For their own protection it's fortunate our native orchids grow in places not overly frequented by people. Their numbers could not stand indiscriminate gathering.

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